

Broiler chicken welfare assessment in GLOBALGAP® certified and non-certified farms in Brazil

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Abstract

Regarding broilers, Brazil is the third largest producer and the leading chicken meat exporter in the world. Independent certifications are required by some importers in the European Union (EU) to guarantee compliance with minimum welfare requirements. Our objective was to compare broiler chicken welfare in GLOBALGAP® certified (C) and non-certified (N) intensive farms in the State of Paraná, Brazil, using the Welfare Quality® protocol. Ten farms in each group were evaluated and data were transformed using scores that ranged from 0 to 100, where 100 is the best condition. Results suggested that farms adhered to minimum welfare standards, regardless of certification and that the adoption of standards based on overseas rules may have limitations for the improvement of animal welfare. In order to further improve broiler welfare in Brazil, more rigorous standards should be developed.

Keywords: animal-based assessment, animal welfare, certification, chicken, international trade, Welfare Quality®

Introduction

Poultry is the most traded category of meat in the world, and Brazil is the leading broiler chicken meat exporter (FAO 2013; UBABEF 2014). Animal welfare is becoming increasingly important to international trade (Rushen *et al* 2011), and information on the husbandry conditions of farm animals may influence the purchasing behaviour of consumers (Verbeke 2009). Thus, welfare requirements have been included as a quality attribute by companies in a strategy to promote welfare standards on their products (Main 2008). As regards the export of poultry in Brazil, GLOBALGAP® is the main certification required, especially for those exporting to the European Union (EU). This certification stands for good agricultural practices, including food safety, sustainable production methods, worker and animal health and welfare. Certification schemes may also be helpful in guaranteeing more competitive conditions for farmers in countries with welfare regulations compared with products imported from countries without a specific welfare code (Ingenbleek *et al* 2012). International publications have highlighted deficiencies in the welfare policies of developing countries (Van Horne & Achterbosch 2008; Robins & Phillips 2011), and the weakness of such regulations in these countries, including Brazil, are often considered to lead to poor animal welfare. However, recent evidence-based comparisons of broiler welfare have challenged this interpretation (Tuytens *et al* 2014).

Welfare assessment schemes tend to be based on farm resources and management practices, called inputs. However, animal-based measures, or outcomes, focus on animals and have the advantage of allowing comparisons to be made across farming systems (Heath *et al* 2014). The Welfare Quality® protocol based welfare assessment on mostly animal-based measures (Welfare Quality® 2009), and so the scores obtained in each measure may be compared between different farms. Despite this possibility, only a small number of publications using this protocol exist for broiler chickens.

Considering that farm production schemes in the European Union (EU) contain animal welfare requirements that comply with local regulations or go beyond the legal minimum (Veissier *et al* 2008), it is expected that these certifications would improve animal welfare in regions where no specific welfare policy is in place. According to Ingenbleek *et al* (2012), solutions to improve animal welfare should consider the context of each country, so evidence-based knowledge of the effects of international certification schemes on animal welfare is important to improve discussion on the system benefits in different countries. With this in mind, our objective was to compare broiler chicken welfare in GLOBALGAP® certified and non-certified intensive broiler farms in the State of Paraná, Brazil, using the Welfare Quality® protocol.

Figure 1



Internal view of a broiler chicken farm in the State of Paraná, Brazil, assessed using the Welfare Quality® protocol in August 2013.

Materials and methods

Study animals, facilities and data collection

A total of 20 broiler chicken farms were visited, ten of which were certified (C) by the GLOBALGAP® Integrated Farm Assurance (Poultry Standard, see appendix) and ten were non-certified (N) farms. Certified farms have been on certification schemes from as far back as December 2011. All C and N farms belong to a co-operative integration on the West of the State of Paraná, Brazil (25°17'49.1"S, 54°05'41.7"W), which is approved by the Ministry of Agriculture (MAPA) to export to the European Union (EU). Certified farms were controlled through independent third party audits, and meat products kept their traceability throughout the production process. Farms to be assessed were selected randomly from the slaughterhouse schedule, considering those within two to six days prior to slaughter in the period of the experiment, in August 2013. Two farms, one certified and one non-certified were visited each day. Both groups were represented in morning and afternoon periods. Visits occurred between 0800 and 1200h and between 1300 and 1700h, with a duration of 3 h at each farm. One observer, a veterinarian and poultry farm auditor, performed all farm assessments. The observer underwent training with an experienced individual, initially via video recordings, to elucidate protocol and exercises on gait score assessment. The second step involved practical activity at the University of Paraná farm in order to carry out a full assessment of broiler welfare, according to the Welfare Quality® protocol. All birds were sent to the same slaughterhouse, and condemnation data were provided by the Federal Inspection Service. The co-operative maintained three different types of units for certified and non-certified farms, according to the lighting system: laterals with wire mesh covered by a black-out curtain working as dark and semi-dark houses; and laterals with wire mesh covered by a

yellow curtain, with natural lighting. In order to avoid differences between systems, only yellow curtain units, hereafter named conventional houses, were selected. Birds were male and female Cobb 500®, assessed at 42.0 (\pm 1.5) days of age and at a weight of 2.7 (\pm 0.3) kg. The units had automatic (n = 19) or manual (n = 1) feeders, nipple drinkers (n = 20), sprinklers (n = 20), exhaust fans (n = 20), evaporative cooling systems (n = 20) and floors were covered with wood-shavings (n = 20) (Figure 1). The average area of broiler houses was 1,455 (\pm 110) m² and the number of birds per house was 17,163 (\pm 1,592).

Assessment was performed using the Welfare Quality® protocol for Poultry (Welfare Quality® 2009), and included environmental and animal-based measures of the four welfare principles: Good feeding, Good housing, Good health and Appropriate behaviour (Table 1).

This project was approved by the Animal Use Ethics Committee of the Agricultural Sciences Campus of the Federal University of Paraná, protocol 033/2013.

Scoring system and statistical analysis

Data were transformed into scores that ranged from zero to 100, with 100 being the best. Rates of mortality, culling, ascites, septicaemia, dehydration and abscesses are presented as percentages. The score for each measure was calculated according to the Welfare Quality® protocol (Welfare Quality® 2009; pp 39-50) and criteria and principles scores were calculated by the Choquet Integral available on the Welfare Quality® website (Welfare Quality® 2013). Normality was checked (Shapiro Wilk test) and results analysed via descriptive statistics and compared using the one-tailed Mann-Whitney U test. For all analyses, significance was assessed at the level of 0.05.

Results

Results of Welfare Quality® assessment both on-farm and at the slaughterhouse are shown in Table 2.

Good feeding principle

The number of nipples was higher on C farms (P < 0.05). When you consider that groups showed similar numbers of birds per house, C farms had a lower bird to nipple ratio (P < 0.05), with the median bird to nipple ratio 8.4:1 (7.9–9.6) on C farms compared to 9.1:1 (7.9–12.1) on N farms. The criterion 'absence of prolonged thirst' had a higher score for C farms compared to N (P < 0.05) and, consequently, the principle 'good feeding' also followed suit (Figures 2 and 3). No differences were observed in 'absence of prolonged hunger' (P = 0.3), with an emaciation prevalence of 0.02 (\pm 0.02)%.

Good housing principle

This principle score did not differ between groups (P = 0.28). The criterion score for 'comfort around resting', ie the integration of plumage cleanliness, litter quality and dust sheet test measures, also showed no difference between groups (P = 0.11), but C farms demonstrated better litter quality compared to N farms (P < 0.05; Figure 4).

Table 1 Principles, criteria and measures of Welfare Quality® protocol for broilers.

Principle	Criteria	Measure	Method	Place
Good feeding	Absence of prolonged thirst	Drinker space	Bird:nipple ratio	On-farm
	Absence of prolonged hunger	Emaciation	% of carcase condemnation	SLH*
Good housing	Comfort around resting	Plumage cleanliness	Visual inspection of 100 birds in each farm	On-farm
		Litter quality	Visual inspection of six points in each farm, considering the worst on at least 15% of locations	On-farm
	Thermal comfort	Dust sheet test	Visual inspection of dust using a black A4 paper	On-farm
		Panting, huddling	Visual inspection of 100 birds in five locations in each farm	On-farm
Ease of movement	Stocking density	Calculation of kg m ⁻²	On-farm	
Good health	Absence of injuries	Lameness	Visual inspection of walking ability of 150 birds in each farm using a six-point scale	On-farm
		Hock burn	Visual inspection of 100 birds in each farm	On-farm
		Breast blister	Visual inspection on the line during 5 min	SLH*
		Foot-pad dermatitis	Visual inspection of 100 birds in each farm	On-farm
	Absence of disease	On-farm mortality	% of mortality	On-farm
		Culls on-farm	% of culling	On-farm
		Ascites, septicaemia, abscesses, dehydration	% of carcase condemnation	SLH*
Appropriate behaviour	Good human-animal relationship	Touch test	Attempt to touch birds in 21 samples per farm	On-farm
	Positive emotional state	Qualitative behavioural assessment (QBA)	Visual observation of birds for 10 min, recording the level of 23 emotional descriptors on a visual analogue scale	On-farm

* Slaughterhouse.

During the experiment, mean external temperatures ranged from 7.7 to 23.5°C (SIMEPAR 2013), with a consequent variation in mean internal temperatures within broiler houses that ranged from 19.3 to 27.6°C. Assessments of C and N farms were equally distributed across cold and hot days. The thermal comfort did not differ between C and N farms ($P = 0.2$), and presented low scores with external temperatures above 25.0°C. The scores for ease of movement were equal for both groups ($P = 0.23$; Table 2), with an overall stocking density of 32.0 (± 2.8) kg m⁻² or 11.8 (± 0.7) birds per m².

Good health principle

The score for this principle was not calculated as the required data on pericarditis and hepatitis were not recorded by the Federal Inspection Service. The only measure that differed between groups in the criterion 'absence of disease' was abscess prevalence ($P < 0.05$), which was higher for N farms (Table 2). The overall mortality rate was 2.3 (± 0.8)% with culls on-farm 1.1 (± 0.5)% and ascites 0.03 (± 0.03)%. No septicaemia was in evidence. Two N farms presented 0.01% of dehydration. Culls, on-farm, made up 31.7 (16.1–66.6)% and 29.5 (13.6–56.0)% of deaths on C and N farms, respectively. The criterion, 'absence of injuries' includes a number of important welfare issues for broiler chickens, notably

contact dermatitis and lameness; none of which differed between groups (Table 2; $P > 0.05$). Approximately 3.6% of birds (108/3,009 assessed birds) presented gait scores 4 and 5, and the overall mean prevalence of any level of foot-pad dermatitis and hock burn was 57.8% (1,156/2,000) and 26.2% (528/2,008), respectively (Figure 5).

Appropriate behaviour principle

The touch test measure presented high scores and no difference between C and N farms ($P = 0.47$). Certified farm results for QBA were higher than N farms' results ($P < 0.05$); however, it is worth noting that both groups presented low QBA scores (Table 2).

Discussion

Good feeding principle

The method that exists of assessing thirst in chickens in the Welfare Quality® protocol (2009) considers the bird to nipple ratio, although recent evidence suggests that an animal-based measure may be more effective (Sprenger *et al* 2009; Vanderhasselt *et al* 2014). Since broilers should not compete or have difficulties accessing water, the Department for Environment, Food and Rural Affairs (DEFRA) recommends that birds should not walk more than 4 m to reach water or food (DEFRA 2009), and certain protocols

Table 2 Scores and percentages of certified (C) and non-certified (N) broiler chicken farms assessed using the Welfare Quality® protocol, State of Paraná, Brazil, August 2013.

Principle	Criteria	Measure	C farms*	N farms*	Other studies
Good feeding			81.0 ^a (71.0–86.0)	75.0 ^b (52.0–86.0)	
	Absence of hunger	Emaciation	98.0 (94.0–100.0)	98.0 (96.0–100.0)	78.8 (± 9.91) ¹ , 88.0 (57.0–97.0) ² , 82.0 (68.0–91.0) ³
	Absence of thirst	Drinker space	80.0 ^a (68.0–84.0)	73.0 ^b (47.0–85.0)	70.5 (± 25.2) ¹ , 87.0 (82.0–10.0) ² , 46.0 (16.0–80.0) ³
Good housing			40.0 (34.0–63.0)	44.0 (33.0–57.0)	28.9 (± 9.2) ¹
	Comfort around resting		58.0 (31.0–70.0)	45.0 (26.0–72.0)	27.4 (± 7.0) ¹ , 61.0 (40.0–75.0) ² , 43.0 (29.0–56.0) ³
		Plumage cleanliness	62.0 (54.0–77.0)	67.0 (36.0–88.0)	59.0 (39.0–70.0) ² , 47.0 (19.0–55.0) ³
		Litter quality	67.0 ^a (14.0–67.0)	34.0 ^b (14.0–67.0)	100.0 (34.0–100.0) ² , 34.0 (34.0–67.0) ³ , 0.0–14.0 ⁴ , 14.0–34.0 ⁵
		Dust sheet test	53.0 (53.0–78.0)	53.0 (53.0–78.0)	78.0 (53.0–78.0) ^{2,3}
	Thermal comfort	Panting, huddling	34.0 (29.0–100.0)	54.0 (29.0–100.0)	35.6 (20.1) ¹ , 29.0 (19.0–100.0) ^{2,3}
	Ease of movement	Stocking density	43.0 (33.0–55.0)	45.0 (41.0–56.0)	27.4 (± 7.0) ¹ , 53.0 (47.0–64.0) ² , 21.0 (0.0–40.0) ³
Good health					32.3 (± 5.7) ¹ , 21.0 (12.0–26.0) ² , 13.0 (4.0–23.0) ³
	Absence of injuries		34.0 (29.0–41.0)	36.0 (29.0–42.0)	20.0 (± 5.6) ¹
		Lameness	23.0 (22.0–26.0)	24.0 (23.0–25.0)	19.0 (15.0–23.0) ² , 16.0 (13.0–20.0) ³
		Hock burn	55.0 (41.0–81.0)	59.0 (49.0–86.0)	37.0 (25.0–48.0) ² , 35.0 (27.0–41.0) ³
		Foot-pad dermatitis	31.0 (18.0–53.0)	33.0 (20.0–53.0)	26.0 (7.0–30.0) ² , 7.0 (1.0–24.0) ³
		Breast blister	100.0	100.0	99.0 (99.0–99.0) ² , 99.0 (99.0–99.0) ³
	Absence of disease				
		On-farm mortality (%)	2.53 (0.96–3.19)	1.87 (1.21–4.14)	4.7 (2.2–6.5) ² , 3.2 (1.3–8.7) ^{3**} , 2.8 (± 0.4) ^{4***} , 3.9 (± 0.3) ^{5**}
		Culls on-farm (%)	1.17 (0.61–1.92)	0.74 (0.26–2.25)	0.6 (0.2–1.7) ²
		Abscesses (%)	0.00 ^a (0.00–0.03)	0.02 ^b (0.00–0.03)	0.03 ² , 0.05 ⁶ , 0.09 ⁷
		Ascites (%)	0.02 (0.00–0.06)	0.03 (0.00–0.11)	
		Dehydration (%)	0.00 (0.00–0.00)	0.00 (0.00–0.01)	
		Septicaemia (%)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Appropriate behaviour					
	Good human-animal relationship	Touch test	88.0 (45.0–100.0)	89.0 (62.0–100.0)	88.2 (± 11.8) ¹ , 99.0 (69.0–100.0) ² , 95.0 (92.0–100.0) ³
	Positive emotional state	QBA	35.0 ^a (28.0–39.0)	28.0 ^b (20.0–41.0)	32.0 (± 12.6) ¹ , 18.0 (2.0–71.0) ² , 18.0 (0.0–51.0) ³

* Mean (min–max).

¹ Mean (± SD) score of farms assessed in 2011 using the Welfare Quality® protocol (Welfare Quality® 2013).² Median (min–max) score of farms from Brazil assessed in 2011 using the Welfare Quality® protocol (Federici 2012).³ Median (min–max) score of farms from Belgium assessed in 2011 using the Welfare Quality® protocol (Federici 2012).⁴ Mean (± SD) score of farms from The Netherlands assessed in 2008 using the Welfare Quality® protocol (Welfare Quality® 2010).⁵ Mean (± SD) score of farms from Italy assessed in 2008 using the Welfare Quality® protocol (Welfare Quality® 2010).⁶ Mean score of slaughterhouses in Brazil (Jorge 2008).⁷ Mean score of slaughterhouses in Brazil (Coelho 2010).

** On-farm mortality and culls on-farm.

Different superscripts for C and N report statistical difference ($P < 0.05$) between groups using one-tailed Mann-Whitney U test.

Figure 2

Absence of prolonged thirst scores for certified and non-certified broiler chicken farms assessed using the Welfare Quality® protocol, State of Paraná, Brazil, August 2013. Different superscripts show statistical differences between group median scores ($P < 0.05$).



Figure 3

Good feeding scores for certified and non-certified broiler chicken farms assessed using the Welfare Quality® protocol, State of Paraná, Brazil, August 2013. Different superscripts show statistical differences between group median scores ($P < 0.05$).

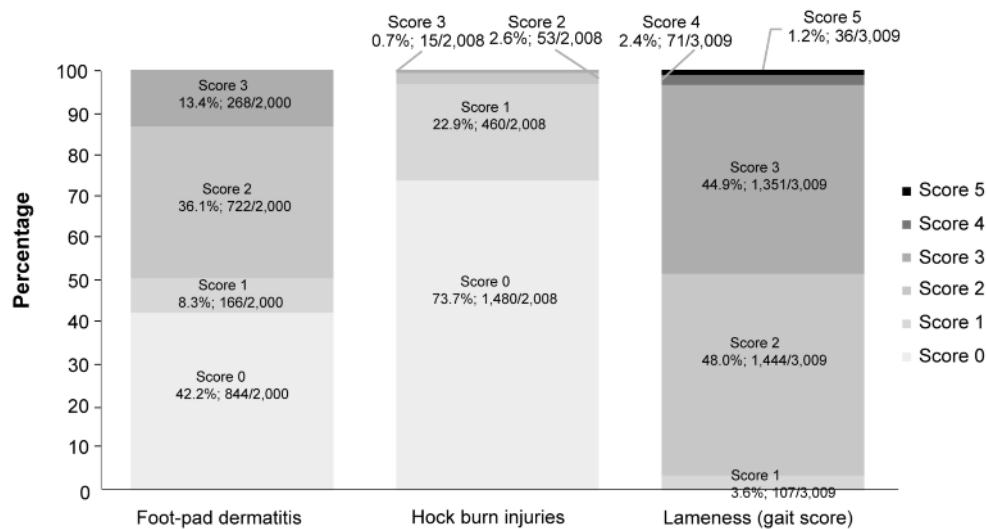


Figure 4

Litter quality measure scores of certified and non-certified broiler chicken farms assessed using the Welfare Quality® protocol, State of Paraná, Brazil, August 2013. Different superscripts show statistical differences between groups median scores ($P < 0.05$).



Figure 5



Overall mean percentages of foot-pad dermatitis, hock burn and lameness on broiler chicken farms assessed using the Welfare Quality® protocol, State of Paraná, Brazil, August 2013. Foot-pad dermatitis and hock burn: score zero is the absence of lesions, scores one and two moderate lesions, scores three and four severe lesions. Gait score: score zero is normal walking, score one is slight abnormality, score two is identifiable abnormality, score three is obvious abnormality, score four is severe abnormality and score five is incapable of walking.

determine a maximum bird to nipple ratio of 10:1 (Welfare Quality® 2009; RSPCA 2011; GLOBALGAP® 2013). When we consider that fewer birds per nipple promotes welfare, C farms provided the best results as regards water access. Welfare assessments of broiler farms using the same protocol as 2011 and 2012 presented scores of 70.5 (\pm 25.2) and 87.0 (82.0–100.0), respectively, for this criterion (Federici 2012; Welfare Quality® 2013), which are in agreement with our results. Results of emaciation were lower than for other studies seen in Brazil, such as 0.19% (Federici 2012) and 0.54% (Jorge 2008). One possible factor for this could be the common practice in this co-operative of culling emaciated birds throughout the rearing process. Our results suggest that the criterion ‘absence of prolonged hunger’ can be considered satisfactory in both groups.

Good housing principle

Both groups showed better results for this principle in comparison to scores of farms assessed by the Welfare Quality® group (Welfare Quality® 2013; Table 2). Considering the criterion, ‘comfort around resting’, previous work presented low to moderate scores (Federici 2012; Welfare Quality® 2013; Table 2). According to Malleau *et al* (2007), intensive broiler meat chicken systems are not able to offer an appropriate environment for birds to rest, and Buijs *et al* (2010) observed that broiler resting behaviour and spatial distribution are affected by higher stocking densities such as 12.1 birds per m². Considering that broiler welfare is influenced greatly by rearing condition (Dawkins *et al* 2004), these results also indicate that further improvements are necessary in order to increase both the standard of housing condition and comfort around resting.

The quality of litter is a recognised welfare problem on broiler farms which impacts on animal health (de Jong *et al* 2014). As it is dependent upon many factors, such as litter material, drinker maintenance, stocking density and housing conditions (SCAHAW 2000), different results are expected between studies and these range from poor conditions to excellent (Table 2). Litter quality impacts on plumage cleanliness (Berg 2004), however, our final scores for these measures did not confirm this trend. The median grade for litter quality was one and zero for C and N farms, respectively, where zero represents the best condition and four the worst. However, the final calculated scores were moderate to low (Table 2). This can be a consequence of the method described in the Welfare Quality® protocol (2009) to calculate the final score, which considers the worst litter grade in 15% of observations, and the small litter sampling of four to six locations per farm. It may thus be difficult to make any correlation between the litter quality score and the score of items influenced by litter quality (ie plumage cleanliness, contact dermatitis, air quality). Grandin (2013) suggests that litter quality can be evaluated by animal-based measures such as plumage, foot-pad dermatitis and hock burn. In our study these animal-based measures were similar between groups.

Considering the criterion, ‘thermal comfort’, other similar studies (Federici 2012; Welfare Quality® 2013; Table 2) also observed low scores. Temperatures observed inside broiler houses were higher than the 18°C considered to be comfortable for this breed at 42 days of age (Cobb-Vantress® 2013), and high temperatures were also identified in other studies in Brazil, such as 26.4 (\pm 1.8) and 28.2 (\pm 1.5)°C (Menezes *et al* 2010). This makes hyperthermia the main thermal discomfort as regards broiler production (SCAHAW 2000) and is a critical factor influencing their welfare.

The results for the criterion, 'ease of movement' in Brazilian conventional broiler houses were in accordance with Federici (2012; Table 2), with a mean (\pm SEM) stocking density of 27.6 (\pm 0.9) kg m⁻². These moderate results could perhaps be a consequence of the conventional open houses in both studies. Similar studies on totally enclosed broiler houses showed higher stocking densities, such as those demonstrated by Welfare Quality® (2010) in The Netherlands; 42.6 (38.6–45.5) kg m⁻² and 45.5 (39.9–48.8) kg m⁻², and by Tuytens *et al* (2008) in Belgium; 18.9 (\pm 1.2) birds per m². In our study, broiler house construction is carried out in integration systems under the co-operative's guidance and, according to Robins and Phillips (2011), system standardisation tends to occur. Thus, similar results for broiler house area were expected, but not for the number of birds per house and, consequently, stocking density. Considering that the co-operative only implemented the certification scheme in a number of farms sufficient to supply a specific market, N farms were not obliged to follow the same stocking density rates. This would suggest that certification requirements do not differ from the density rates seen in conventional farms in Brazil.

Good health principle

According to SCAHAW (2000), modern broiler breeds are not subject to a satisfactory level of welfare, including health. Welfare Quality® research presented a score of 32.3 (\pm 5.7) in 2011 for this principle, and the result was a consequence of the low score for the criterion 'absence of injuries' (Welfare Quality® 2013), which contains two important broiler welfare problems: lameness and contact dermatitis. Low scores in the criterion 'absence of injuries' were also observed in our study (Table 2). This indicates poor animal welfare and a need for immediate action. Genetic selection in modern broiler breeds has created a vulnerability to health problems, especially lameness (Dawkins & Layton 2012), and the Cobb500® breed has already been described as a carrier of leg problems (Robins & Phillips 2011). The percentage of birds in this study with gait score four and five, that are described as having great difficulty or being unable to walk, is similar to other results that ranged from 3.3 to 6.6% (Knowles *et al* 2008; Welfare Quality® 2010). According to EFSA (2010), gait score should be monitored on farms and reducing the number of birds with scores of four and five must be a high priority as regards genetic selection. Breeding companies have provided lines for various types of broilers, and the final choice from available phenotypes is made by the producer or customer (EFSA 2010). Since the certification scheme of C farms considers the choice of more resistant breeds as merely a recommendation and not a non-compliance item (GLOBALGAP® 2013), it is unlikely that certification will act to reduce leg problems via genetics.

Contact dermatitis is an important welfare indicator (Bessei 2006; Robins & Phillips 2011). In the literature, the percentage of birds with any level of foot-pad dermatitis varied from 64.5 to 82.0% (Allain *et al* 2009; Gouveia *et al* 2009; de Jong *et al* 2012; Federici 2012). Lesion severity is

also highly significant as a result of the pain (Caplen *et al* 2013) that may affect birds. In a study using the same method as here, the percentages of severe lesions observed were 48.9 (\pm 5.5) and 52.8 (\pm 6.0)% in The Netherlands and 35.0 (\pm 6.7) and 24.8 (\pm 3.7)% in Italy (Welfare Quality® 2010). Bassler *et al* (2013), using a different scoring system, identified 37.1% of broiler chickens with moderate and severe foot-pad dermatitis, and Haslam *et al* (2007) observed the mean percentage of 11.0% of moderate and severe foot-pad dermatitis in the United Kingdom, measured at the slaughterhouse. Comparison between studies is difficult due to different methods of assessment and experimental design (EFSA 2010), however, despite this, it is clear that foot-pad dermatitis occurs in a moderate to high frequency in intensively raised broiler chickens and may be considered an important factor in improving welfare. The occurrence of other contact dermatitis, such as hock burn and breast blister, was lower than foot-pad dermatitis. Hock burn levels were in accordance with Berg (2004) who estimated a prevalence of 7.0 to 20.0%. Bassler *et al* (2013) identified a low prevalence of broiler chickens with moderate and severe hock burn (7.9%) while for breast blister, Menzies *et al* (1998) and Federici (2012) showed similar results of about 0.0 and 0.2%. Economic incentives to farmers may help to decrease the prevalence of contact dermatitis, particularly the more severe lesions. This was shown in a study by Ekstrand *et al* (1998) on the prevalence of foot-pad dermatitis in Sweden following implementation of a Government-led programme of poultry foot health. In our study, the economic incentive is private, subsidised by the co-operative, and this could have been more important to farmers than the certification, leading to similar results between groups.

According to the European Commission (2007), the calculated mortality rates for the age of the birds in this study is 3.3 to 3.6%. Mortality itself does not directly reflect animal welfare, but the relationship between mortality and culls, on-farm, is an important welfare indicator (EFSA 2010). According to the Welfare Quality® (2009), when 20 to 50% of deaths are due to culling, the maximum mortality rate should be 3.5%, which is in accordance with mortality medians observed on C and N farms. Regarding this study's certification scheme, culling animals with gait scores of 4 and 5 or those struggling to reach water and food is mandatory. Due to similar culling results on C and N farms, it is possible that this practice of limiting animal suffering became widespread among farmers.

Percentages of abscesses were similar or lower than in other studies in Brazil (Table 2). Ascites, dehydration and septicaemia warning percentages were 0.5 to 0.75% (Welfare Quality® 2009), which suggests that those diseases are not critical points for animal welfare on assessed farms.

Appropriate behaviour principle

High scores have also been found for the criterion 'good human-animal relationship' in other studies (Table 2), which suggests good human-animal relationships. Otherwise, the positive emotional state presented low

scores in other studies (Table 2), suggesting poor welfare for this criterion. Some inherent factors of broiler chicken systems can contribute to bad results on emotional state, such as barren environments (Jones 1996) and low animal activity due to artificial selection (EFSA 2010).

Animal welfare implications

Certification is an important tool in helping to promote improvements. However, the certification scheme studied here may be more effective in improving animal welfare in totally enclosed poultry barns, where the stocking density tends to be greater, than in conventional farms in Brazil. Results from N farms also suggest that the certification process in itself may promote indirect effects on companies through the inclusion of new concepts that can be adopted by the production chain. Despite the small number of certified broiler chicken farms and the minimal broiler chicken welfare regulation in Brazil, international welfare codes of practice are available to companies and global demands are monitored by the Ministry of Agriculture, in partnership with the Brazilian Chicken Producers and Exporters Association.

Based on our results, it seems relevant that the welfare assessment be based on local characteristics of Brazilian boiler chicken systems, including the decision regarding which animal welfare requirements should be part of the certification scheme. Through the observation of low scores on critical health points, such as lameness and foot-pad dermatitis on C farms, we reinforce the importance of including animal-based measures on certification schemes to better improve animal welfare, as suggested by other authors (Veissier *et al* 2008; Main *et al* 2014), in addition to the existing environment-based measures. Moreover, to further improve animal health in certified farms, the GLOBALGAP® certification scheme should consider the choice of a more resistant breed as mandatory, since other work has shown significant breed differences in welfare outcomes (EFSA 2010).

Results presented here refer to conventional poultry houses. As Brazil is replacing conventional farms with window-less and force-ventilated houses (Pulici 2012), broiler chicken welfare may be adversely affected as a consequence of low levels of artificial illumination and increased stocking density (EFSA 2010). More research is desirable to evaluate the benefits and losses of this process to animal welfare in Brazil.

Conclusion

The certified farms presented better results regarding access to water, litter quality, abscesses and QBA, but no differences were observed for other broiler chicken critical welfare issues, such as lameness, panting and contact dermatitis. Results suggest that farms were attaining the required minimum welfare standard irrespective of certification and that the adoption of standards based on foreign rules may have limitations on animal welfare improvement. In order to further improve broiler welfare, more rigorous standards should be developed and included within certification schemes.

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